(19) JAPANESE PATENT OFFICE (JP)

(12) Official Gazette for Laid-Open Patent Applications (A)

(11) Japanese Laid-Open Patent Application (Kokai) No. H10-243979

(43) Disclosure Date: September 14, 1998

(51)Int. Cl.[6]	Classification Symbols	FI	
A 61 H 1/02		A 61 H 1/02	R
A 63 B 22/02		A 63 B 22/02	
24/00		24/00	

Request for Examination: Not yet submitted

Number of Claims: 5 OL (Total of 8 pages [in original])

(21) Application No. H09-50019

(22) Filing Date: March 5, 1997

(71) Applicant: 000005108
Hitachi, Ltd.
4-6 Kanda-Surugadai, Chiyoda-ku, Tokyo

(72) Inventor: Tomoyuki Tani
c/o Mechanical Engineering Research Laboratory, Hitachi Ltd.
502 Kandatsu-machi, Tsuchiura-shi, Ibaraki-ken

(72) Inventor: Akihiko Sakai
c/o Mechanical Engineering Research Laboratory, Hitachi Ltd.
502 Kandatsu-machi, Tsuchiura-shi, Ibaraki-ken

(72) Inventor: Atsushi Ozeki
c/o Mechanical Engineering Research Laboratory, Hitachi Ltd.
502 Kandatsu-machi, Tsuchiura-shi, Ibaraki-ken

(72) Inventor: Shizuko Hattori
c/o Mechanical Engineering Research Laboratory, Hitachi Ltd.
502 Kandatsu-machi, Tsuchiura-shi, Ibaraki-ken

(72) Inventor: Seiji Iizuka
c/o Refrigeration & Air Conditioning Division, Hitachi Ltd.
800 Ooaza-Tomida, Oohira-machi, Shimotsuga-gun, Tochigi-ken

(72) Inventor: Takao Nagata
c/o Hitachi Tochigi Electronics Co., Ltd.

709-2 Ooaza-Tomida, Oohira-machi,Shimotsuga-gun, Tochigi-ken

(72) Inventor: Tooru Horie

c/o Refrigeration & Air Conditioning Division, Hitachi Ltd.

800 Ooaza-Tomida, Oohira-machi, Shimotsuga-gun, Tochigi-ken

(74) Agent: Katsuo Ogawa, Patent Attorney

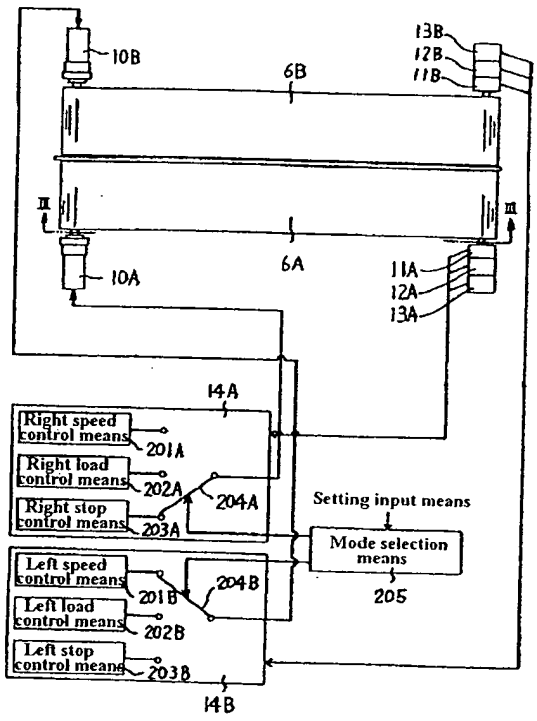
(54) **[Title of Invention] Walking Training Device**

(57) **[Abstract]**

[Issue] The object of the present invention is to provide a walking training device capable of selecting a training mode that trains with a focus on one leg from among other training modes.

[Means of Solution] Provides a switching means 204 that selects, from among a control means for controlling right and left loop belts 6A and 6B that form a trainee's walking surface in various operating modes, an operating mode that holds one loop belt at a fixed position.

FIG. 2



[Claims]

[Claim 1] A walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of said walking surfaces;

wherein said control device is provided with a means for continuously controlling one of said walking surfaces at a fixed position.

[Claim 2] A walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of said walking surfaces;

wherein it is provided with independent left and right means for fixing one of said walking surfaces.

[Claim 3] A walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of said walking surfaces;

wherein said control device is provided with a means that holds one of said walking surfaces at a fixed position and controls so that only the other walking surface can run.

[Claim 4] A walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device controlling the respective running of said walking surfaces;

wherein said control device is provided with a first control means that detects the state of the walking surface and controls the running of the walking surfaces independently for left and right, a second control means that holds one of said walking surfaces at a fixed position and controls so that only the other walking surface can run, and a selection means for selecting said first and second control means.

[Claim 5] A walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of said walking surfaces;

wherein said control device has a plurality of control modes, and is provided with a selection means for selecting the plurality of control modes independently for the left and right walking surfaces respectively.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention pertains to a walking training device that can provide simulated walking as physical exercise in a small space.

[0002]

[Prior Art]

Japanese Laid-open Patent Application H08-141027 discloses a walking training device for a trainee who needs to maintain or recover his walking function. This device is provided

with a walking path means in which the trainee's walking surface is constituted by a loop belt, and a means for controlling the running speed of the loop belt. It is additionally provided with a means for setting the load characteristics of the above-described walking path means, a means for detecting the running speed of the above-described loop belt, and a means for calculating the control rules for the above-described walking path means using the above-described load characteristics and running speed.

[0003]

[This document] describes the actual equivalent mass, equivalent damping coefficient, or equivalent spring constant of the walking path means as the load characteristics of the walking path means, and describes a formula for calculating the drive force of the walking path means as control rules using the above-described load characteristics along with the resistance force of the drive mechanism of the walking surface and displacement of the loop belt. In addition, [the document] discloses a constitution of a control device that controls the drive force of the walking path means – that is, the walking surface – based on the above-described control rules.

[0004]

Furthermore, [this document] discloses that the above-described device can be implemented as a passive walking training device that operates at a speed corresponding to the force at which a trainee kicks the walking surface.

[0005]

[Problems the Invention Is to Solve]

However, the above-described prior art did not adequately consider training a trainee when the strength of one leg is greatly inferior to that of the other leg. That is, in the case of a trainee with a considerable difference in leg strength between his two legs or when both legs have considerable functional impairment, sometimes it is preferable to train one leg at a time instead of training both legs at once. In this case, in the above-described prior art there is the possibility that the two belts, left and right, corresponding to the left and right legs will end up running [inadvertently] by detecting the force a trainee carelessly applies to them.

[0006]

Therefore the object of the present invention is to provide a walking training device capable of selecting a training mode that trains with a focus on one leg from among a plurality of training modes.

[0007]

[Means for Solving the Problems]

In order to achieve the above-described object, the present invention is a walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of the above-described walking surfaces; the above-described control device is provided with a means for continuously controlling one of the above-described walking surfaces at a fixed position.

[0008]

Furthermore, in order to achieve the above-described object, the present invention is a walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of the above-described walking surfaces; it is provided with independent left and right means for fixing one of the above-described walking surfaces.

[0009]

Furthermore, in order to achieve the above-described object, the present invention is a walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of the above-described walking surfaces; the above-described control device is provided with a means that holds one of the above-described walking surfaces at a fixed position and controls so that only the other walking surface can run.

[0010]

In this case, for the means that holds one of the walking surfaces at a fixed position, a means that controls a walking surface at a fixed position or a means that mechanically fixes a walking surface can be considered. A mechanically fixing means that can be considered is one that controls this by means of a control device; the simplest example of this control is switching between a fixed state and an unfixed state, for example.

[0011]

Furthermore, in order to achieve the above-described object, the present invention is a walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device controlling the respective running of the above-described walking surfaces; the above-described control device is provided with a first control means that detects the state of the walking surface and controls the running of the walking surfaces independently for left and right, a second control means that holds one of the above-described walking surfaces at a fixed position and controls so that only the other walking surface can run, and a selection means for selecting the above-described first and second control means.

[0012]

Furthermore, in order to achieve the above-described object, the present invention is a walking training device comprising a walking surface device having two walking surfaces, left and right, and a control device independently controlling the respective running of the above-described walking surfaces; the above-described control device has a plurality of control modes, and is provided with a selection means for selecting the plurality of control modes independently for the left and right walking surfaces respectively.

[0013]

Given the above-described constitutions, when one leg is on a walking surface that can be considered stopped or stopping, it is possible to do training of the other leg on a walking surface that can run or is running. When doing so, the walking surface corresponding to the above-described other leg may always be driven at a fixed speed, or it may be controlled so that the speed or the reaction force the trainee receives from the walking surface changes so as to control the running state according to the force applied to the walking surface from a leg.

[0014]

[Preferred Embodiments of the Invention]

Below, embodiments of the present invention are explained based on drawings. FIG. 1 is a drawing showing the overall constitution of the inventive walking training device 1. The walking training device 1 is provided with a walking surface device 2, control device 3, support device 4, and display 5. The control device 3 is constituted so it can be separated from the walking surface device 2; the two are electrically connected by a cable. Furthermore, the control device 3, in addition to the walking surface device 2, also controls driving the support device 4 and controls the display of the display 5.

[0015]

Below, each constituent element is explained. The walking surface device 2 is explained using FIG. 2 and FIG. 3. FIG. 2 is a drawing showing the walking surface device 2 seen from above, and FIG. 3 is a drawing showing a cross section of the walking surface device 2 of FIG. 2 at arrows III-III. Furthermore, part of the constitution of the control device appears in FIG. 2 also, but this will be explained later. The walking surface device 2 is fixed on the floor or ground; it has a walking surface 6 on which the trainee rides and does walking training. The walking surface 6 has a right foot walking surface 6A and a left foot walking surface 6B, constituted as loop belts that work independently of one another. The two loop belts that form these walking surfaces (in the explanation below, the walking surface is referred to as a loop belt) are disposed parallel in close contact.

[0016]

The right and left loop belts 6A and 6B are arranged, as shown in FIG. 3, so they run stretched between right and left drive rollers 7A and 7B and right and left slave rollers 8A and 8B. When doing so, free rollers 9 are disposed between the drive roller and the slave roller; they hold the loop belt in a way that helps the loop belt run.

[0017]

In this case, a sensor may also be provided to detect sinking or bending deformation of the free rollers 9 so that the trainee's foot stepping on can be detected. If this sensor is provided at the plurality of free rollers 9 along the longitudinal direction of the loop belt, it is also possible to detect the position at which the foot stepped on.

[0018]

Meanwhile, as shown in FIG. 2, the drive rollers 7A and 7B are rotationally driven by right and left motors 10A and 10B, which are the drive means, and the right and left loop belts 6A and 6B are driven and run. When doing so, provided on the right and left slave rollers 8A and 8B are belt speed detection means 11A and 11B for detecting the speed of the loop belts 6A and 6B as they rotate, belt displacement detection means 12A and 12B for detecting displacement of the loop belts 6A and 6B, and belt acceleration detection means 13A and 13B for detecting the acceleration of the loop belts 6A and 6B.

[0019]

The support device 4 is explained using FIG. 1 and FIG. 4. FIG. 4 shows the situation when a trainee is supported in the support device 4, seen from the side. The support device 4 is for supporting the trainee on the walking surface device 2, and provides a support arm 41 with a round cushion provided on both sides of the trainee's body, a handle 42 with a grip 44 so that the

trainee can grasp it, and a force sensor provided between the support arm 41 and handle 42. Furthermore, a back belt 46 provided so that it connects between the two support arms 41 provided at both sides of the trainee's body and a pelvis belt 45 worn at the trainee's hips are detachably provided at the rear end of the support arm 41. 43 is a force sensor that detects force applied to the support device 4 by the trainee; it is provided between the handle 42 and support arm 41.

[0020]

The above-described support device is arranged to support the trainee's hips, but if the subject is a trainee with increased leg strength, one may also provide a safety device such as a grab bar the trainee can grasp at both sides and the front of the walking surface device instead of the above-described support device 4.

[0021]

Next, the control device 3 is explained using FIG. 1, FIG. 2, and FIG. 5. The control device 3, as shown in FIG. 1, comprises a display device 31 such as a CRT, for example, a keyboard (including mouse) 32 as the input means, and a calculation device (not shown in the drawing). FIG. 1 is a view of the system constitution, but the functions and purposes of the control device 3 is explained using FIG. 3 [sic]. The control device 3 is provided with a calculation means 14, information preprocessing means 15, information display means 16, database 17, and setting input means 18. Furthermore, a signal bus 19 links [those] to a motor 10 that is the drive means for the walking surface device 2 and various sensor means (11~13).

[0022]

The setting input means 18 is a means for inputting setting values for operating modes when doing walking training (the details will be described later) and for all operating modes, independently for right and left loop belts 6A and 6B respectively. The keyboard 32 in FIG. 1, etc. is used.

[0023]

The information preprocessing means 15 performs conversion processing such as unit conversion, etc. on information from the detection means (11~13) and from the calculation means 14 in order to display it on the information display means 16, and it does conversion processing such as differentiation or integration of information from the detection means (11~13) and sends it to the calculation means 14. For example, even if the information from the detection means (11~13) is only speed, performing differentiation can produce acceleration and performing integration can produce distance. Furthermore, a display device 31 such as the CRT of FIG. 1 is used as the information display means 16.

[0024]

The calculation means 14 calculates the control amount for controlling the motors 10A and 10B, which are the drive means. It utilizes the output of various sensors – for example, the encoder prepared as speed detection means 9 of the loop belt – according to settings by the setting input means 18.

[0025]

In calculating this control amount, it is possible to employ calculation based on control rules as disclosed in Japanese Laid-open Patent Application H08-141027, for example. When doing so, the database 17 is provided in order to store the load characteristics of the walking surface device or different control rules (formulas), etc. The actual equivalent mass, equivalent damping coefficient, or equivalent spring constant, etc. that were used to model the structure of the walking surface device are used as load characteristics. Furthermore, the above-described document discloses a plurality of control rules, but a passive walking training device that operates at a speed corresponding to the force at which a trainee kicks the walking surface can be implemented using a desired value for the above-described load characteristics and the speed of the loop belt or the external force acting on the loop belt (loop belt tension).

[0026]

Incidentally, a walking training device in accordance with the present invention is provided with a training mode that trains with either one of the loop belts, left or right, essentially stopped. The training modes of the walking training device of this embodiment, including this training mode, shall be explained.

[0027]

First, the trainee cases can be categorized into the following three cases, according to differences in ability to move the legs.

Case 1: Muscle force for moving the legs is very weak; basically, just up and down movement.

Case 2: Can move leg forward and backward, but force when kicking the path surface is very small.

Case 3: Can move leg forward and backward and kick the path surface.

[0028]

On the other hand, four operating modes for the right and left loop belts 6A and 6B, which can be set from the setting input means 18, are prepared as follows.

[0029]

(1) Stop (Fixed) Mode

A belt is fixed or held in a fixed position so that the loop belt does not move. Methods for practicing this mode are, for example, a method that constitutes a position feedback control system inside the calculation means 14 using the integrated value of the output of the displacement detection means 12 or speed detection means 11, or a method that uses applying a brake to the motor 10, the drive means.

[0030]

(2) Speed Control Mode

Movement at a target speed, with the speed of loop belt 6 input from the setting input means 13 [sic]. A method for practicing this mode is, for example, constituting a speed feedback control system inside the calculation means 14 using the belt speed detection means 9.

[0031]

In this speed control mode the running speed of the loop belt 6 may be a constant speed or the speed may be varied. In addition, when changing the speed, the acceleration may be changed gradually by detecting when the trainee's foot steps on. In addition, it is possible to determine the speed pattern based on the difference in the position at which the foot steps on and the position at which the foot lifts, and to lessen or adjust the burden on the trainee. In this case, a method can be considered wherein the loop belt is driven and accelerated after [the trainee] steps on, and it is controlled to slow it down so as to stop when the foot lifting position is reached.

[0032]

Detection of the foot lifting position and stepping on position can be done using the sensors provided in the above-described free rollers.

[0033]

(3) Load Control Mode

The load of the loop belt 6 as perceived by the trainee is controlled to be the load input from the setting input means 13 [sic]. The control disclosed in Japanese Laid-open Patent Application H08-141027, for example, can be used as this control mode. The details are omitted here, but a passive walking training device that operates at a speed corresponding to the force at which a trainee kicks the walking path means can be implemented by employing active impedance control and setting the load characteristics of the walking surface device 6 as perceived by the trainee, and additionally by applying force to drive the loop belt 6 so as to assist kicking. Moreover, the load characteristics can be freely modified according to the leg ability of the trainee. This control mode is suitable for maintaining and strengthening a muscular strength of the leg, especially in case 3, where the path surface can be kicked.

[0034]

In load control mode the drive force assisting the kick is large enough to cancel resistance force such as the friction, etc. of the mechanism of the walking path surface, so in a no-load state the loop belt is stationary. Therefore a trainee U needs to kick the loop belt, regardless of the magnitude of the force.

[0035]

If the drive force assisting the kick becomes large, it can also be employed in case 2, where the leg can be moved forward and backward but force when kicking the path surface is very small. This system in particular is called drive assist mode. Drive assist mode is explained in detail next.

[0036]

(4) Drive Assist Mode

This control mode, same as the load control mode, employs active impedance control. The load characteristics of the walking path means are determined as perceived by the trainee, and in addition a force to drive the loop belt 6 so as to assist kicking is applied, and enough drive force to assist the kick is applied until the loop belt moves at a constant speed with the trainee U not riding on the loop belt, i.e. [the belt] in a no-load state.

[0037]

Drive assist mode can be applied to case 1, where there is no kicking force, or to case 2. Moreover, operation occurs at a speed that corresponds to the kicking force, so it is possible to make the speed correspond to the movement of the trainee's leg even if the force kicking the path surface is very small while it is possible to move the leg forward and backward, as in case 2.

[0038]

By using the four operation (control) modes described above it is possible to do training according to a trainee's condition.

[0039]

Furthermore, trainees who require walking training often have functional impairment such as apoplexy (single leg paralysis) or a bone fracture, etc. in either the left or right leg. For this type of trainee it may be preferable to train by selecting a different operation mode for the left and right loop belts.

[0040]

FIG. 2 shows a constitution for this type of case; it provides a switching means (selection means) that switches (selects) so as to make the operating modes for the loop belts different for left and right. A calculation means 14A for the right-side loop belt and a calculation means 14B for the left-side loop belt are provided in the calculation means 14 of the control device 3. These are prepared as software, of course.

[0041]

A right-side speed control means 201A, right-side load control means 202A, and right-side stop control means 203A are provided as software in the calculation means 14A for the right-side loop belt. Similarly, a left-side speed control means 201B, left-side load control means 202B, and left-side stop control means 203B are provided as software in the calculation means 14B for the left-side loop belt. The above-described speed control means is a control means that implements the above-described speed control mode, the load control means is a control means that implements the load control mode and drive assist mode, and the stop control means is a means that implements stop mode.

[0042]

The load characteristics, etc. and necessary data needed for each control mode of the walking surface device are stored in the database 17 of FIG. 5.

[0043]

In addition, as shown in FIG. 2, the various control means 201A~203A for the right-side loop belt and the various control means 201B~203B for the left-side loop belt can be appropriately selected using the switching means 204A and 204B. When doing so, a mode selection means 205 selects the appropriate control means from the calculation means 14A for the right-side loop belt and the calculation means 14B for the left-side loop belt, according to the indication of the mode for selection from the setting input means 18. These switching means 204A and 204B are also implemented as software.

[0044]

At this time, it is even more convenient if commands or keys indicating various combinations are prepared in advance, and the mode selection means 205 selects the appropriate control means from the calculation means 14A for the right-side loop belt and the calculation means 14B for the left-side loop belt by operating these commands or keys.

[0045]

Next, the training method is explained when different operating modes are selected for the right and left loop belts. Regarding the trainee's legs, the leg on the side with a functional impairment shall be referred to as the disabled side leg, and the side with no impairment shall be referred to as the healthy side leg.

[0046]

1) Stop mode is selected for the loop belt for the disabled side leg; for the loop belt for the healthy side leg, speed control mode, load control mode, or drive assist mode is selected.

[0047]

In general, a patient with a functional impairment in a leg on one side has few opportunities to use the leg because the disabled side does not function fully, and as a result often the healthy side leg also weakens due to insufficient movement. This training method can perform the movement for only the healthy side leg.

[0048]

A case in which even the healthy side leg is greatly weakened is equivalent to case 1 or case 2. Speed control mode or drive assist mode is employed for this type of trainee. For case 1, speed control mode is employed. If the speed target value is increased each time the training repeats, it is believed that muscle strength gradually recovers and the trainee will become able to move his leg forward and backward. For case 2, drive assist mode is employed.

[0049]

If the functioning of the healthy side leg is equivalent to case 3, load control mode is employed.

2) Stop mode is selected for the loop belt for the healthy side leg; for loop belt for the disabled side leg, speed control mode, load control mode, or drive assist mode is selected.

[0050]

Using this method it is possible to train at a speed or load corresponding to the ability of the disabled side leg only.

[0051]

A case in which the disabled side leg is greatly weakened is equivalent to case 1 or case 2. Speed control mode or drive assist mode are mainly employed for this type of trainee. For case 1, a constant speed system is employed. If the speed target value is increased each time the training repeats, it is believed that muscle strength gradually recovers and the trainee will become able to move his leg forward and backward. For case 2, drive assist mode is employed.

[0052]

If the functioning of the disabled side leg is equivalent to case 3, load control mode is employed. But if one attempts to employ load control mode on the disabled side leg, it may be possible to shift to training using both sides.

[0053]

3) Both the loop belts for the disabled side leg and the healthy side leg are in load control mode, but the size of the load on the disabled side leg is smaller than on the healthy side leg. This system in employed in case 3, where even though there is a difference in left and right leg force, there is kicking force.

[0054]

The burden on the disabled side leg is lessened compared to the healthy side leg, so the trainee can walk with the speed of the disabled side leg the same as that of the healthy side leg. As a result, there is good left/right balance, and it is possible to walk with correct posture.

[0055]

The size of the load is made to approach that of the healthy side leg as the disabled side leg recovers. When the difference in the loads on the disabled side leg and healthy side leg become small, it is possible to conclude that the trainee's leg function has become the same for left and right.

[0056]

4) Speed control mode is selected for the loop belt for the healthy side leg and drive assist mode or load control mode is selected for the loop belt for the disabled side leg. This is employed for a trainee when the function of the healthy side leg is close to that of a normal healthy person and the function of the disabled side leg is case 2 or case 3. The trainee consciously walks and trains so that the speed of the loop belt for the disabled side leg becomes the same as the speed of the loop belt for the healthy side leg.

[0057]

5) Load control mode is selected for the loop belt for the healthy side leg and drive assist mode is selected for the loop belt for the disabled side leg. This is employed for a trainee when the function of the healthy side leg is close to that of a normal healthy person and the function of the disabled side leg is case 2 or case 3. The trainee consciously walks and trains so that the speed of the loop belt for the disabled side leg becomes the same as the speed of the loop belt for the healthy side leg.

[0058]

6) Speed control mode is selected for both loop belts, but walking training is performed with the speed of the loop belt for the disabled side leg set slower than that of the healthy side leg. This is employed for a trainee when the function of the healthy side leg is close to case 3 and the function of the disabled side leg is case 2.

[0059]

7) Walking training is performed with the loop belt for the disabled side leg in drive assist mode and the loop belt for the healthy side leg in speed control mode. When the speed difference between the disabled side leg and the healthy side leg become small, it is possible to

conclude that the trainee's leg function has become the same for left and right. This is employed for a trainee when both the healthy side leg and disabled side leg are case 2 but the disabled side leg has weakened.

[0060]

In addition to the modes described above, a mode for stopping both the right and left loop belts 6A and 6B may also be provided. Doing so makes it easy to get on and off the loop belts and to make various settings while on the loop belts.

[0061]

Furthermore, in addition to the modes described above, a mode wherein one can halt the running of both left and right loop belts or either one of them and be able to train while manually adjusting the running speed may also be provided. For example, a grip 44 of the handle 42 in FIG. 1 can be utilized as the control part. That is, a detector to detect angle of rotation is provided in the grip 44, and when the trainee rotates the grip 44 the running speed of the loop belts changes according to the angle of rotation. In this case, speed control to make the target speed correspond to the angle of rotation should be performed by the calculation means 14, but even if high-precision speed feedback control is not performed, it is possible for the trainee to train while making fine adjustments of the speed on his own so as to match his own pace. When doing so, a selection means is provided to specify that the loop belt undergoing speed adjustment is both left and right, right only, or left only. Furthermore, the loop belt that is not selected may be run in any of the operating modes noted above. Furthermore, in order to prevent the trainee from mistakenly giving the grip 44 a big rotation if his posture collapses, at least one of either the back belt 46 or pelvis belt 45 may be provided, supported by the support arm. In addition, a means may be provided to change (adjust) the sensitivity of running speed changes in the loop belts relative to the angle of rotation of the grip 44. This eliminates the feeling of inconvenience in grip operability even if the range of speed used varies according to the different trainees. This type of means can easily be constituted using the setting input means 18 and calculation means 14 or the database 17.

[0062]

Another embodiment of the walking surface device 2 is explained using FIG. 6. A sliding sheet 602 on a table 601 are provided instead of the free rollers 9 used in FIG. 3. The table 601 functions as a member supporting the loop belts 6A and 6B, and the sliding sheet 602 reduces frictional resistance when the loop belts 6A and 6B run. The sliding sheet 602 can even be constituted by applying a Teflon process to a metal table surface, for example.

[0063]

As explained above, a walking training device that provides a walking path means to form a walking path for a trainee is provided with a walking path means that functions as walking surfaces that operate independently for the left and right legs of the trainee. The left and right walking path means can independently select different operating systems:

(1) A system (load control system) that measures one or more of the walking path means' displacement, speed, or acceleration, drives the walking path means according to control rules using these, and controls the load characteristics of the walking path means as perceived by the trainee.

(2) A system (drive assist system) that applies enough drive force to assist a kick until the walking path means moves at a constant speed even when the trainee is not on the walking means, i.e. when it is in a no-load state, and then employs the load control system.

(3) A system (speed control system) that operates so that the speed of the walking path means becomes the set speed.

(4) A system (walking path fixed system) that fixes the walking path means so it cannot move.

Thus it is possible to do walking training in a state which cannot be implemented when walking on an ordinary path surface.

[0064]

This is particularly effective when training a trainee whose right leg or left leg is weaker than the other due to apoplexy, etc.

[0065]

[Effect of the Invention]

Providing a means that holds either the left or right walking surface at a fixed position makes it possible to select a training mode that trains optimally with the focus on one leg.

[Brief Description of the Drawings]

FIG. 1: A structural system view (external appearance) of a walking training device.

FIG. 2: A view of the walking surface device, seen from above.

FIG. 3: A sectional view at arrows III-III of the walking surface device of FIG. 2.

FIG. 4: A structural view of a support means, seen from the side.

FIG. 5: A view explaining the functions and purposes of the structure of the control device 3.

FIG. 6: A view explaining another embodiment of the walking surface device.

[Explanation of Symbols]

1 Walking training device 1

2 Walking surface device

3 Control device

4 Support device

6 Walking surface

10 Motor

11 Belt speed detection means

12 Belt displacement detection means

13 Belt acceleration detection means

14 Calculation means

15 Information preprocessing means
16 Information display means
17 Database
18 Setting input means
19 Signal bus
42 Handle
44 Grip
201 Speed control means
202 Load control means
203 Stop control means
204 Switching means
205 Mode selection means
601 Table
602 Sliding sheet

FIG. 1

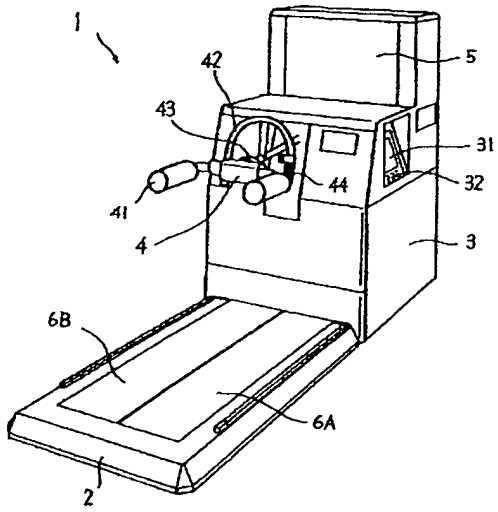


FIG. 3

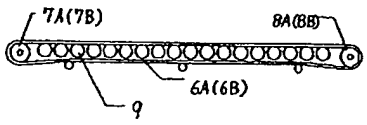


FIG. 4

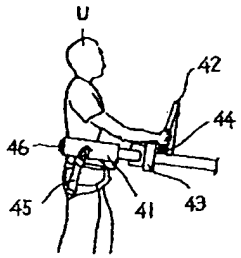


FIG. 6

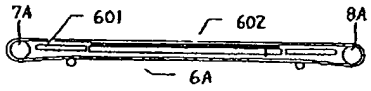


FIG. 5

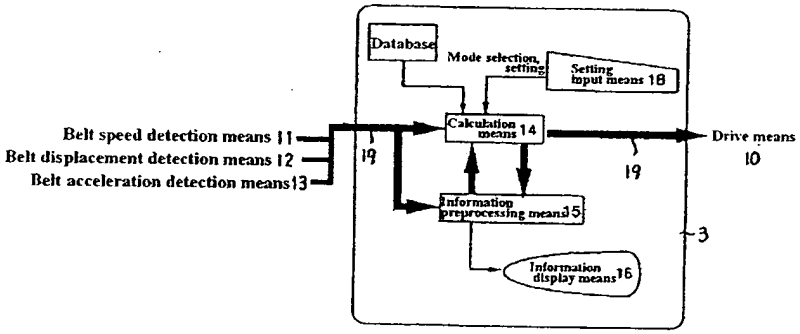
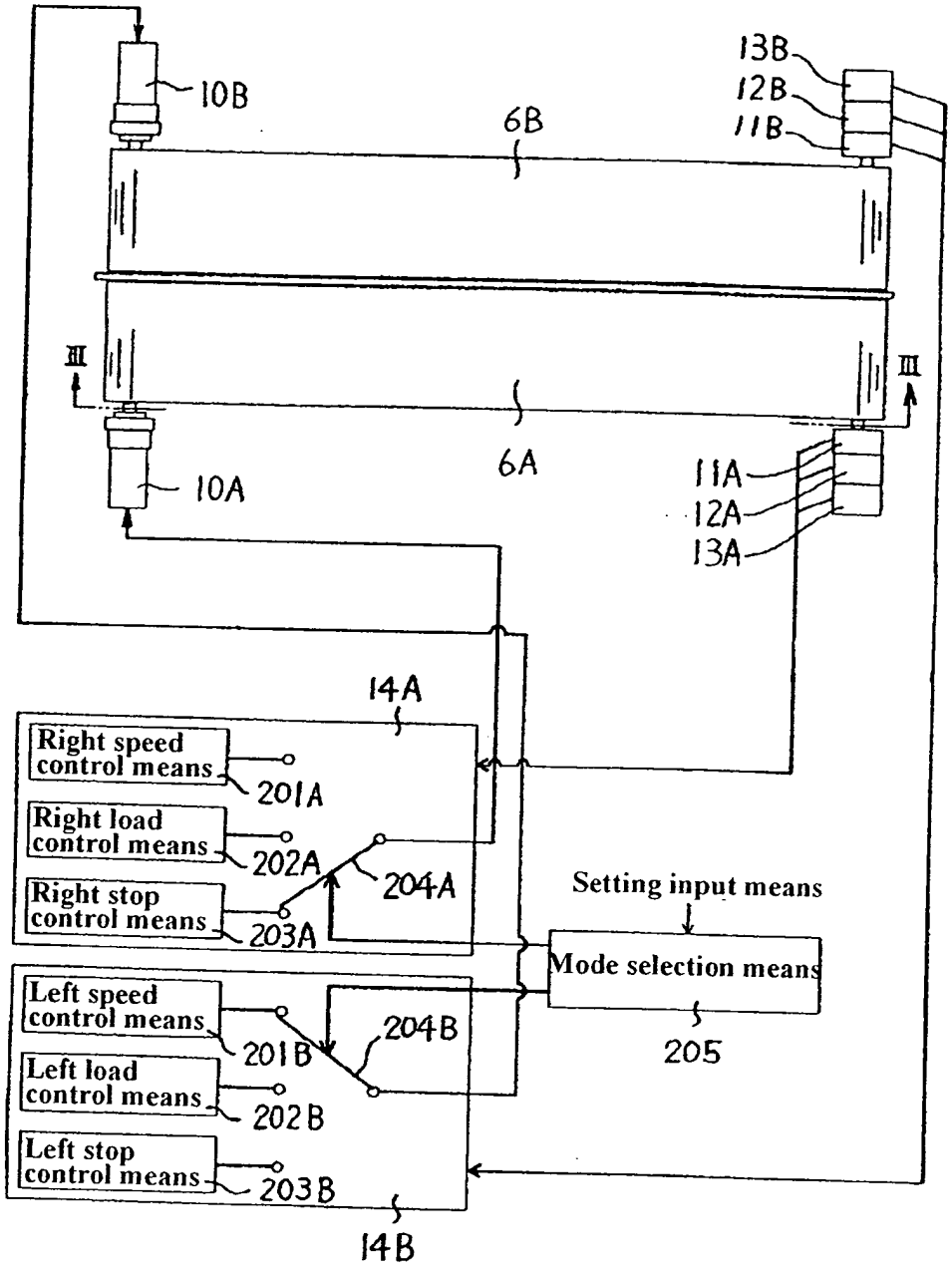


FIG. 2


10B
6B
13B
12B
11B
III
III
6A
10A
11A
12A
13A
14A
Right speed control means
201A
Right load control means
202A
204A
Right stop control means
203A
Setting input means
Mode selection means
205
Left speed control means
201B
204B
Left load control means
202B
Left stop control means
203B
14B

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平10－243979

(43)公開日　平成10年(1998)９月14日

(51)Int.Cl.[6]	識別記号	ＦＩ	
Ａ６１Ｈ　1/02		Ａ６１Ｈ　1/02	Ｒ
Ａ６３Ｂ　22/02		Ａ６３Ｂ　22/02	
24/00		24/00	

審査請求　未請求　請求項の数５　ＯＬ　（全８頁）

(21)出願番号　特願平9－50019

(22)出願日　平成９年(1997)３月５日

(71)出願人　000005108
株式会社日立製作所
東京都千代田区神田駿河台四丁目６番地

(72)発明者　谷　知之
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内

(72)発明者　酒井　昭彦
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内

(72)発明者　小関　篤志
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内

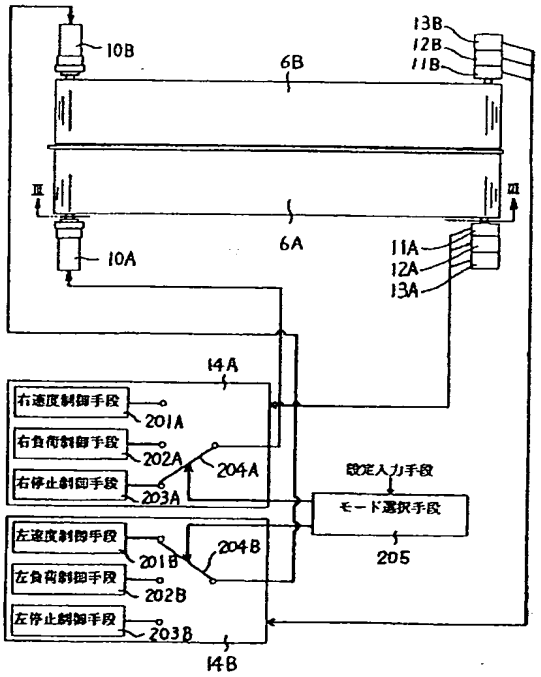
(74)代理人　弁理士　小川　勝男

最終頁に続く

(54)【発明の名称】　歩行訓練装置

(57)【要約】
【課題】本発明の目的は、その他の訓練モードの中から、片方の脚に注目した訓練を行う訓練モードを選択可能にしたことを特徴とする歩行訓練装置を提供することにある。
【解決手段】訓練者の歩行面となる左右の環状ベルト６Ａ，６Ｂを各種の動作モードで制御する制御手段の中から、片方の環状ベルトを一定位置に保持する動作モードを選択する切換手段２０４を設ける。

(図２)



【特許請求の範囲】
【請求項１】左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、
前記制御装置は、前記歩行面の片方を一定の位置に制御し続ける手段を備えたことを特徴とする歩行訓練装置。
【請求項２】左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、
前記歩行面の片方を固定する手段を左右独立に備えたことを特徴とする歩行訓練装置。
【請求項３】左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、
前記制御装置は、前記歩行面の片方を一定の位置に保持し、他方の歩行面のみを走行可能に制御する手段を備えたことを特徴とする歩行訓練装置。
【請求項４】左右２つの歩行面を有する歩行面装置と、前記歩行面の走行を制御する制御装置とを備えた歩行訓練装置において、
前記制御装置は、歩行面の状態を検出して左右独立に歩行面を走行制御する第１の制御手段と、前記歩行面の片方を一定の位置に保持して他方の歩行面のみを走行可能に制御する第２の制御手段と、前記第１及び第２の制御手段を選択する選択手段とを備えたことを特徴とする歩行訓練装置。
【請求項５】左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、
前記制御装置は複数の制御モードを有し、この複数の制御モードを左右の歩行面のそれぞれに独立して選択する選択手段を備えたことを特徴とする歩行訓練装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、省スペースで疑似歩行が体験できる歩行訓練装置に関する。
【０００２】
【従来の技術】特開平８－１４１０２７号公報には、歩行機能の維持又は回復を必要とする訓練者のための歩行訓練装置が開示されている。この装置では、訓練者の歩行面を環状ベルトで構成した歩道手段と、環状ベルトの走行速度を制御する手段とを備え、さらに、前記歩道手段の負荷特性を設定する手段と、前記環状ベルトの走行速度を検出する手段と、前記負荷特性と走行速度とを用いて前記歩道手段の制御則を演算する手段とを備えている。
【０００３】このとき、歩道手段の負荷特性として歩道手段の実質的な等価質量、等価減衰係数又は等価ばね定数が、また制御則として前述の負荷特性の他、歩行面の駆動機構がもっている抵抗力及び環状ベルトの変位を用いて歩道手段の駆動力を演算する数式が記載されている。さらに、前述の制御則に基づいて歩道手段の駆動力、すなわち歩行面を制御する制御装置の構成が開示されている。
【０００４】そして上述の装置では、訓練者が歩行面を蹴る力に応じた速度で運動する、受動的な歩行訓練装置が実現できることが開示されている。
【０００５】
【発明が解決しようとする課題】しかし、上記従来技術では、一方の脚の力が他方の脚に比べて著しく劣った訓練者が訓練を行うことについては、十分な配慮が成されていなかった。すなわち、両脚で脚力にかなり差のある訓練者、或いは両脚ともにかなりの機能障害を有しているの場合、両脚を一度に訓練するのではなく、片方ずつ訓練する方が好ましい場合がある。この場合、上記従来技術では、左右の脚に対応した左右２本のベルトがそれぞれ訓練者が無意識に加えた力を検知して走行してしまう可能性があった。
【０００６】そこで本発明の目的は、複数の訓練モードの中から、片方の脚に注目した訓練を行う訓練モードを選択可能にしたことを特徴とする歩行訓練装置を提供することにある。
【０００７】
【課題を解決するための手段】上記目的を達成するために、本発明は、左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、前記制御装置は、前記歩行面の片方を一定の位置に制御し続ける手段を備えたものである。
【０００８】また、上記目的を達成するために、本発明は、左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、前記歩行面の片方を固定する手段を左右独立に備えたものである。
【０００９】また、上記目的を達成するために、本発明は、左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、前記制御装置は、前記歩行面の片方を一定の位置に保持し、他方の歩行面のみを走行可能に制御する手段を備えたものである。
【００１０】このとき、歩行面の片方を一定の位置に保持する手段には、歩行面を一定の位置に制御する手段や歩行面を機械的に固定する手段が考えられる。機械的に固定する手段では、これを制御装置によって制御するものとし、この制御の最も単純な例としては固定状態と非固定状態を切り換えることが考えられる。
【００１１】また、上記目的を達成するために、本発明は、左右２つの歩行面を有する歩行面装置と、前記歩行面の走行を制御する制御装置とを備えた歩行訓練装置において、前記制御装置は、歩行面の状態を検出して左右

独立に歩行面を走行制御する第１の制御手段と、前記歩行面の片方を一定の位置に保持して他方の歩行面のみを走行可能に制御する第２の制御手段と、前記第１及び第２の制御手段を選択する選択手段とを備えたものである。

【００１２】また、上記目的を達成するために、本発明は、左右２つの歩行面を有する歩行面装置と、前記歩行面の走行をそれぞれ独立に制御する制御装置とを備えた歩行訓練装置において、前記制御装置は複数の制御モードを有し、この複数の制御モードを左右の歩行面のそれぞれに独立して選択する選択手段を備えたものである。

【００１３】上記の各構成によれば、一方の脚を停止或いは停止しているとみなせる歩行面上におき、他方の脚を走行可能或いは走行している歩行面上で訓練することができる。このとき、前記他方の脚に対応する歩行面は、常に一定速度で駆動しても良いし、脚から歩行面に加えられる力に応じて走行状態を制御する場合のように、速度或いは訓練者が歩行面から受ける反力が変化するように制御しても良い。

【００１４】

【発明の実施の形態】以下、本発明の実施例を図面に基づいて説明する。図１は、本発明の歩行訓練装置１の全体的構成を示す図である。歩行訓練装置１は、歩行面装置２、制御装置３、支持装置４及びディスプレイ５とを備えている。制御装置３は、歩行面装置２とは分離可能に構成されており、両者はケーブルで電気的に接続されている。また、制御装置３は、歩行面装置２の他、支持装置４の駆動制御及びディスプレイ５への表示制御も行う。

【００１５】以下、各構成要素について説明する。図２及び図３を用いて歩行面装置２を説明する。図２は歩行面装置２を上から見た図であり、図３は図２の歩行面装置２のIII－III矢視断面を示す図である。尚、図２には、制御装置の構成も一部記載されているが、これについては後で説明する。歩行面装置２は床面又は地上に固定され、訓練者が上に乗って歩行訓練する歩行面６を有する。この歩行面６には、互いに独立に動く環状ベルトで構成された右足用歩行面６Ａ，左足用歩行面６Ｂがあり、これらの歩行面を成す二つの環状ベルト（以下、歩行面を環状ベルトと呼んで説明する。）は平行かつ密接に配置されている。

【００１６】左右の環状ベルト６Ａ，６Ｂは、図３に示すように、左右の駆動ローラ７Ａ，７Ｂと左右の従動ローラ８Ａ，８Ｂとの間に張り渡されて走行するようになっている。このとき、駆動ローラと従動ローラの間には、フリーローラ９が配され、環状ベルトの走行を助けるように環状ベルトを支持している。

【００１７】このとき、訓練者の足が着地したことを検出できるように、フリーローラ９の沈み込み或いは曲げ変形を検出するセンサを設けても良い。このセンサが環状ベルトの長手方向に沿って複数のフリーローラ９に設けられれば、足の着地した位置をも検出することが可能になる。

【００１８】一方、図２に示すように、駆動ローラ７Ａ，７Ｂは、駆動手段である左右のモータ１０Ａ，１０Ｂによって回転駆動され、左右の環状ベルト６Ａ，６Ｂが走行駆動される。このとき、左右の従動ローラ８Ａ，８Ｂには、その回転に伴って環状ベルト６Ａ，６Ｂの速度を検出するベルト速度検出手段１１Ａ，１１Ｂ、環状ベルト６Ａ，６Ｂの変位を検出するベルト変位検出手段１２Ａ，１２Ｂ、及び環状ベルト６Ａ，６Ｂの加速度を検出するベルト加速度検出手段１３Ａ，１３Ｂが設けられている。

【００１９】支持装置４を図１及び図４を用いて説明する。図４は訓練者が支持装置４に支持された状態を側面から見たところである。支持装置４は訓練者を歩行面装置２上に支持するためのものであり、訓練者の身体の両側方に設けられた丸形クッションを有するサポートアーム４１と、訓練者が掴まることができるようにグリップ部４４を有するハンドル４２と、サポートアーム４１とハンドル４２との間に設けられた力センサとを備えている。また、サポートアーム４１には、その後端に、訓練者の身体の両側方に設けられた両サポートアーム４１の間を結ぶように備え付けられた後方ベルト４６と、訓練者の腰部に装着される腰ベルト４５とが着脱可能に備えられている。４３は訓練者から支持装置４に加えられる力を検出する力センサで、ハンドル４２とサポートアーム４１の間に設けられている。

【００２０】上記の支持装置は、訓練者の腰部を支持するようにしたものであるが、脚力の向上した訓練者を対象とする場合には、上記支持装置４に代えて、歩行面装置の両側部及び前面に、訓練者が掴まる手すりなどの安全装置を設けても良いであろう。

【００２１】次に、図１、図２及び図５を用いて、制御装置３について説明する。制御装置３は、図１に示すように、例えばＣＲＴのような表示装置３１、入力手段であるキーボード（マウス含む）３２、演算装置（図示せず）を含んで構成される。図１はシステム構成図であるが、図３を用いて制御装置３を機能本意に説明する。制御装置３は、演算手段１４、情報前処理手段１５、情報表示手段１６、データベース１７、及び設定入力手段１８を備えている。また、歩行面装置２の駆動手段であるモータ１０や各検出手段（１１～１３）とは信号バス１９により連結されている。

【００２２】設定入力手段１８は、左右の環状ベルト６Ａ，６Ｂそれぞれ独立に、歩行訓練時の動作モード（詳細は後述する）および各動作モードでの設定値を入力する手段であり、図１のキーボード３２等を用いる。

【００２３】情報前処理手段１５は、情報表示手段１６に表示させるために、検出手段（１１～１３）や演算手

段１４からの情報に対して単位の換算などの変換処理を行ったり、検出手段（１１～１３）からの情報を、微分や積分などの変換処理を行って演算手段１４に送るなどの処理を行う。例えば、検出手段（１１～１３）からの情報が速度のみであっても、微分をすれば加速度が、積分をすれば距離が得られることになる。また、情報表示手段１６は、図１のＣＲＴのような表示装置３１を用いる。

【００２４】演算手段１４は、設定入力手段１８からの設定に従い、各種センサ、例えば環状ベルトの速度検出手段９として用意されたエンコーダの出力を利用して、駆動手段であるモータ１０Ａ，１０Ｂを制御する制御量を演算する。

【００２５】この制御量の演算としては、例えば、特開平８－１４１０２７号公報に開示されているような制御則に基づく演算を適用することが可能である。このとき、データベース１７は、歩行面装置の負荷特性、或いは異なる制御則（数式）等を記憶しておくために備えられる。負荷特性としては、歩行面装置の機構系ををモデル化したときの実質的な等価質量、等価減衰係数又は等価ばね定数等が用いられる。また、上記公報には複数の制御則が開示されているが、前記負荷特性の所望値と、環状ベルトの速度或いは環状ベルトに作用する外力（環状ベルトの張力）を用いて、訓練者が歩行面を蹴る力に応じた速度で運動する、受動的な歩行訓練装置を実現できる。

【００２６】ところで、本発明に係る歩行訓練装置では、左右の環状ベルトのうち、いずれか一方を実質的に停止させて訓練する訓練モードを備える。この訓練モードを含めて、本実施例の歩行訓練装置が有する訓練モードについて説明する。

【００２７】まず、訓練者の奨励は、脚を動かす能力の差によって次の３症例に分類できる。

症例１：脚を動かす筋力が極めて弱く、ほとんど上下動するのみ。

症例２：脚を前後に動かすことは出来るが、路面を蹴る力は極めて小さい。

症例３：脚を前後に動かし、路面を蹴ることも出来る。

【００２８】一方、設定入力手段１８から設定できる、左右の環状ベルト６Ａ，６Ｂの動作モードには、次の４通りを用意する。

【００２９】(1)停止（固定）モード

環状ベルトが動かぬよう、ベルトを固定或いは一定位置に保持する。このモードを実現するには、例えば、変位検出手段１２或いは速度検出手段１１の出力の積分値を用いた位置フィードバック制御系を、演算手段１４内に構成する方法、または、駆動手段であるモータ１０にブレーキの付いたものを用いる方法がある。

【００３０】(2)速度制御モード

環状ベルト６の速度を設定入力手段１３から入力された速度目標で動かす。このモードを実現するには、例えば、ベルト速度検出手段９を用いた速度フィードバック制御系を演算手段１４内に構成する方法がある。

【００３１】この速度制御モードにおいては、環状ベルト６の走行速度は一定速度であっても良いし、速度を変化させることも考えられる。さらに、速度を変化させる場合は、訓練者の足が着地したのを検知して徐々に加速するようにしても良い。さらに、着地した足の位置と立ち足位置との差から速度パターンを決めるようにして、訓練者の負担を軽減或いは調整するようにしても良い。この場合、着地してから環状ベルトを駆動かつ加速し、立ち足位置に来たときに停止するよう減速制御する方法が考えられる。

【００３２】この立ち足位置及び着地位置の検出は上述のフリーローラに設けたセンサを用いて行うことができる。

【００３３】(3)負荷制御モード

訓練者から見た環状ベルト６の負荷が、設定入力手段１３から入力された負荷になるよう制御する。この制御モードとしては、例えば、特開平８－１４１０２７号公報に開示された制御を用いることができ、ここでは詳細な説明を省略するが、能動インピーダンス制御を適用し、被訓練者から見た歩行面装置６の負荷特性を定め、さらに蹴りを補助するように環状ベルト６を駆動する力を与えることにより、被訓練者が歩道手段を蹴る力に応じた速度で運動する、受動的な歩行訓練装置を実現するものである。しかも被訓練者の脚の能力に応じて負荷特性を自在に変更できる。この制御モードは、特に路面を蹴ることの出来る症例３に対して、脚の筋力の維持増強を行うのに適している。

【００３４】負荷制御モードでは、蹴りを補助する駆動力は歩行路面の機構が持つ摩擦などの抵抗力を打ち消す程度の大きさとしているため、無負荷の状態で環状ベルトは静止している。そのため被訓練者Ｕは、力の多少に関わらず、環状ベルトを蹴ることが要求される。

【００３５】また蹴りを補助する駆動力を大きなものにすれば、脚を前後に動かすことは出来るが路面を蹴る力は極めて小さい症例２に対して適用することも可能である。この方式を特に駆動補助モードと呼ぶ。続いて駆動補助モードの詳細を述べる。

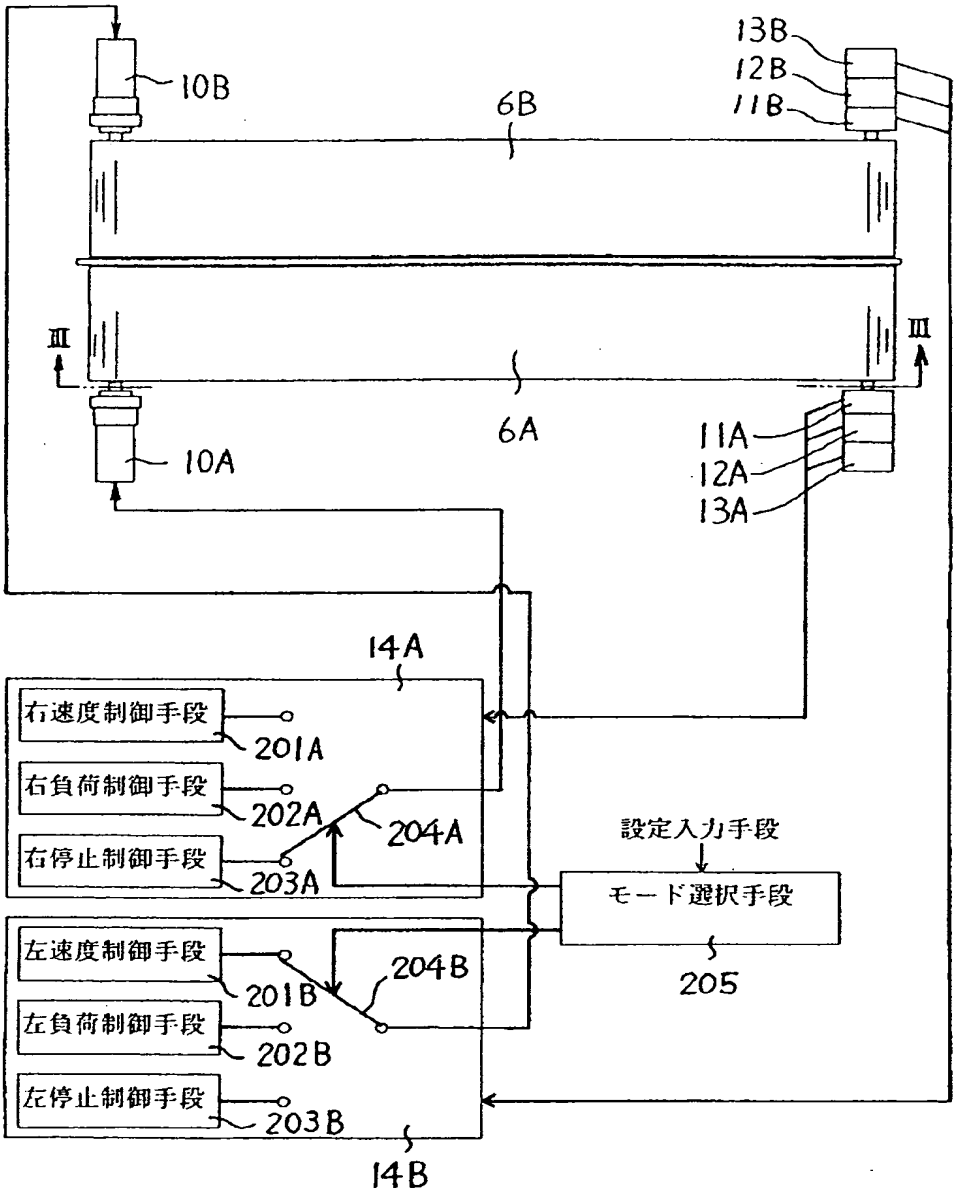
【００３６】(4)駆動補助モード

この制御モードは負荷制御モードと同様に、能動インピーダンス制御を適用し、被訓練者から見た歩道手段の負荷特性を定め、さらに蹴りを補助するように環状ベルトを駆動する力を与えるものであるが、被訓練者Ｕが環状ベルトに乗っていない、つまり無負荷の状態で、環状ベルトが一定の速度で動く程度にまで蹴りを補助する駆動力を加えている。

【００３７】駆動補助モードは蹴る力のない症例１や症例２に対しても適用可能であり、しかも蹴る力に応じた

【図2】

（図 2）



フロントページの続き

(72)発明者　服部　静子
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内
(72)発明者　飯塚　清次
栃木県下都賀郡大平町大字富田800番地　株式会社日立製作所冷熱事業部内
(72)発明者　永田　孝夫
栃木県下都賀郡大平町大字富田709の２　株式会社日立栃木エレクトロニクス内
(72)発明者　堀江　徹
栃木県下都賀郡大平町大字富田800番地　株式会社日立製作所冷熱事業部内